

PC-Based Supercomputing for Uncertainty and Sensitivity Analysis of Models

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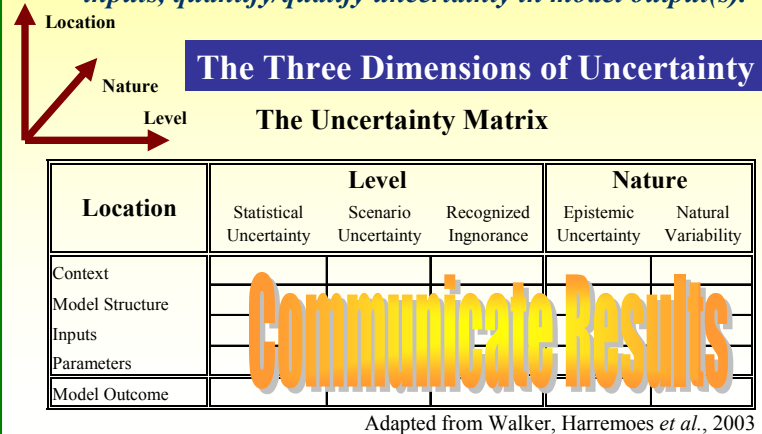
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Uncertainty Analysis

...describing potential differences between model predictions and nature.

Uncertainty (UA): due to lack of knowledge and data.

Analysis → given uncertainty in both models and their inputs, quantify/qualify uncertainty in model output(s).



Quantitative Aspects of UA/SA/PE:

- Many techniques and methods available, improving constantly.
- Current knowledge and execution capabilities usually limited to a select few, out of reach from most model developers and model users.
- An “**embarrassingly parallel**” computational problem; solutions involve running a model over and over with slightly different inputs.
- Many EPA models written for Windows, but most supercomputing solutions today require “mainframes” or Linux-based PC clusters.

The UA/SA/PE Runtime Problem

- As model complexity, time & space grid density, or types of uncertainty and sensitivity analyzed increases, computational burden (runtime) typically **increases geometrically**.
- Greatest reason UA/SA/PE techniques not widely applied to EPA models is **lack of Windows based computer processing capacity**.
- General trend → typical to see PC-based model developers increase model complexity over time, **offsetting concurrent gains in CPU speed**.
- Depending on the EPA model/application, **need 100's to 10's of millions of model simulations**.

Runtime Problem Solution for PC-Models → SuperMUSE Supercomputer for Model Uncertainty and Sensitivity Evaluation



Why Facilitate Use of Model UA/SA/PE?

- Communicate prediction uncertainty to decision makers.
- Identify critical gaps in knowledge and data.
- Increasing technical focus for regulatory-driven litigation.
- We are called upon to establish validity, trustworthiness, and relevance in model predictions. (*Chen and Beck, 1999*)

Sensitivity Analysis & Parameter Estimation

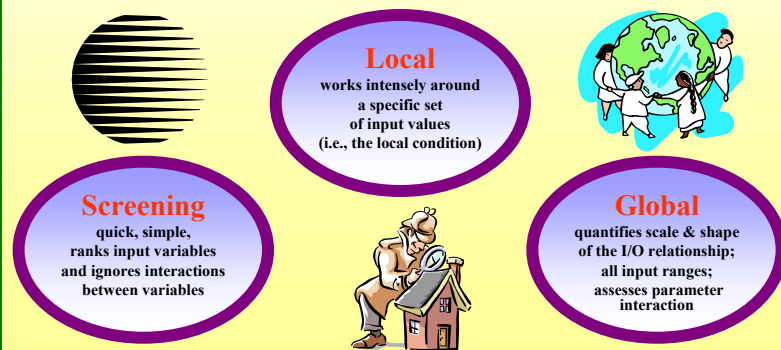
...discovering relationships between model predictions and unit changes in input variables.

Sensitivity (SA): finding the subset of input variables that are most responsible for variation in model output.

Analysis → relate importance of uncertainty in inputs to uncertainty in model output(s).

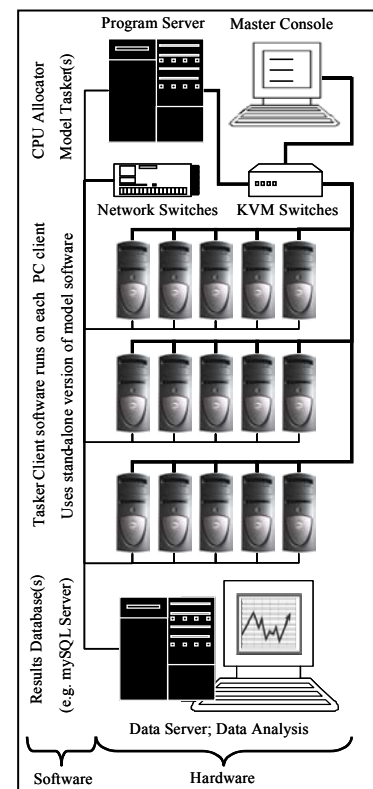
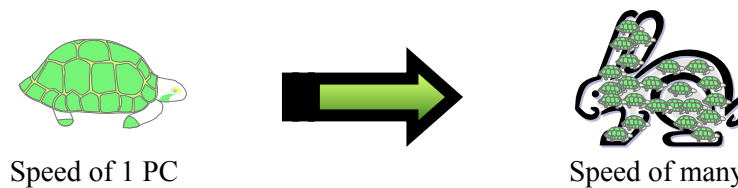
Parameter Estimation (PE): use measured output(s) to back-calculate best estimates of (some) model inputs.

Input Space Assessment Techniques

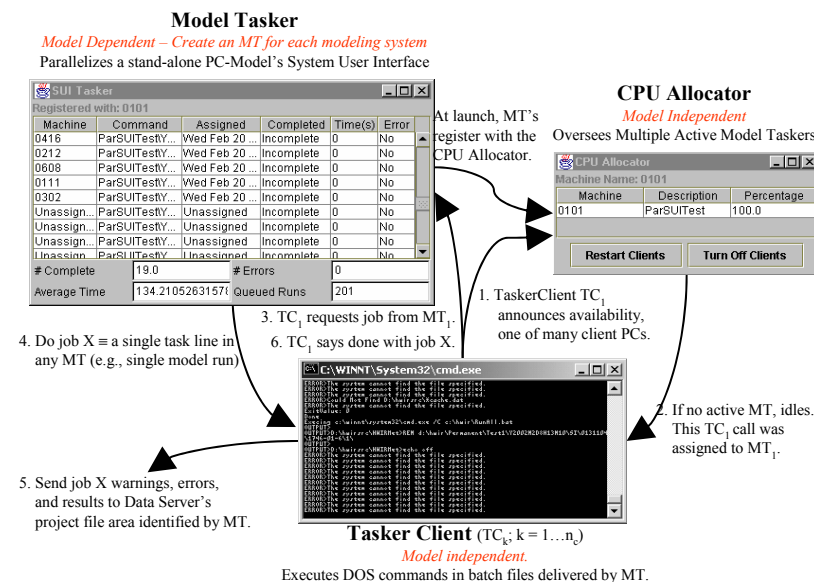


Key Words: Model, Uncertainty, Sensitivity, Parameter Estimation, Multimedia, Supercomputing

Clustering to Increase Computational Capacity



Conceptual Layout of SuperMUSE Hardware & Software Solutiontools to parallelize stand-alone PC-based models



Beneficial Impacts of PC-Based SuperMUSEing

- ✓ SuperMUSE is scalable to individual user (or program & regional office) needs; clustering from 2 to 1000+ PCs.
- ✓ Supports Windows or Linux based modeling systems.
- ✓ Can handle PC models with 10's to 1000's of variables.
- ✓ Solves “**embarrassingly parallel**” computing problems.
- ✓ A local solution → empowers model developers and users.
- ✓ Autonomy from supercomputing centers, removes barriers.
- ✓ Simple, inexpensive, can be built/operated by PC novices.
- ✓ Ideal for debugging models and performing UA/SA/PE.
- ✓ Research effort at ERD delivers software tools that can tap the power of other internal/external PC hardware grids.

Collaborations

- Office of Solid Waste, Hazardous Waste Risk Assessments
- Drs. Beck and Osidele, UGA; global sensitivity analyses
- Dr. Hill, USGS; inverse problem software technologies
- Multi-agency workgroup DoE, DoD, NRC, USDA, NOAA